UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MINNESOTA

REGENTS OF THE UNIVERSITY OF MINNESOTA Plaintiff, v. AT&T MOBILITY LLC, Defendant, ERICSSON, INC., and ALCATEL-LUCENT USA INC., Defendants-Intervenors.	Civil Action No. 0:14-cv-04666 JRT/TNL **JURY TRIAL DEMANDED**
REGENTS OF THE UNIVERSITY OF MINNESOTA Plaintiff. v. SPRINT SPECTRUM L.P., et al., Defendants, ERICSSON, INC., ALCATEL-LUCENT USA INC., and NOKIA SOLUTIONS AND NETWORKS US LLC, Defendants-Intervenors.	Civil Action No. 0:14-cv-04669 JRT/TNL **JURY TRIAL DEMANDED**

REGENTS OF THE UNIVERSITY OF MINNESOTA Plaintiff. v. T-MOBILE USA, INC., Defendant, ERICSSON, INC., ALCATEL-LUCENT USA INC., and NOKIA SOLUTIONS AND NETWORKS US LLC, Defendants-Intervenors.	Civil Action No. 0:14-cv-04671 JRT/TNL **JURY TRIAL DEMANDED**
REGENTS OF THE UNIVERSITY OF MINNESOTA Plaintiff. v. CELLCO PARTNERSHIP D/B/A ERICSSON WIRELESS, Defendant, ERICSSON, INC., and ALCATEL-LUCENT USA INC., Defendants-Intervenors.	Civil Action No. 0:14-cv-04672 JRT/TNL **JURY TRIAL DEMANDED**

DEFENDANTS' AND DEFENDANT-INTERVENORS'
OPENING CLAIM CONSTRUCTION BRIEF

TABLE OF CONTENTS

TABLE OF AUTHORITIES

Page(s)

Cases

TABLE OF ABBREVIATIONS

Abbreviation	Keyword	Exhibit Number
’185	USP 8,718,185	
’230	USP RE45,230	
’309	USP 8,774,309	
’317	USP 8,588,317	
’768	USP 7,251,768	
’768 FH	File History for ’768	2, 11, 12
10/850,961 FH	File History for 10/850,961	8
15/163,055 FH	File History for 15/163,055	13
Baltersee	Baltersee: “Achievable Rate of MIMO Channels …” (2001)	6
CFO	Carrier frequency offset	
CFO Patents	’309, ’185, and ’317, collectively	
CoC	Certificate of Correction for U.S. Patent No. RE45,230	5
Data & Telecommunications Dictionary	Data & Telecommunications Dictionary (1999)	4
Defendants	Defendants and Defendant-Intervenors	
Feuersanger	Feuersanger, “An iterative Channel Estimation …” (2000)	9
HIPERLAN/2	HIPERLAN/2 Standard (2001)	10
JCC	Joint Claim Construction Statement, ECF No. 298[1]	
MIMO	Multiple-input multiple-output	
Newton’s	Newton’s Telecommunications Dictionary (19th ed. 2003)	3

[1] ECF numbers herein are in No. 0:14-cv-04666 JRT/TNL.

NIST	National Institute of Standards and Technology	
OFDM	Orthogonal Frequency Division Multiplexing	
Plaintiff	Plaintiff Regents of the University of Minnesota	
Plaintiff's Interrog. Responses	Plaintiff's Answers to Defendants' First Set of Common Interrogatories (Feb. 11, 2016).	7
POSITA	Person of ordinary skill in the art	
VDW	Declaration of Daniel van der Weide, Ph.D.	

I. INTRODUCTION

Defendants and Intervenors ("Defendants") respectfully submit this Brief in support of their proposed constructions of the disputed terms of the asserted claims. For further information on the technology underlying these patents, see the declaration of Daniel van der Weide, Ph.D. at ¶29-66. Section II addresses the disputed terms relating to U.S. Patent Nos. RE45,230 and 7,251,768. Section III addresses the disputed terms relating to U.S. Patent Nos. 8,774,309, 8,718,185, and 8,588,317.

II. DISPUTED TERMS IN THE '230 AND '768 PATENTS

A. "a precoder that applies a liner [sic] transformation to the constellation symbols to produce precoded symbols" ('768 cl. 1) / "a precoder that linearly precodes the constellation symbols" ('768 cl. 13) / "linearly precoding the constellation symbols by applying a linear transformation to produce precoded symbols" ('768 cl. 21)

Defendants	**Plaintiff**
"a precoder that applies a linear transformation to combine two or more of the constellation symbols with each other to produce precoded symbols, wherein the linear transformation has the following properties: 1) For any constellation symbols a and b, f(a + b) = f(a) + f(b) 2) For any scalar k, f(k*a) = k*f(a)"	"a precoder that applies…": a precoder that applies a linear transformation that transforms a block of input symbols into a block of output symbols in which each output symbol is a linear combination, or weighted sum, of input symbols. "linear transformation": a mathematical operation on vectors f(x), which has the property that for any vectors a and b that are valid arguments to f, f(a + b) = f(a) + f(b), and for any scalar k f(k*a) = k*f(a). The linear transformation does not include the operation of using a spreading sequence of chips to spread each information-bearing symbol over a set of data symbols. "a precoder that linearly precodes…": see proposed construction for the phrase "a precoder that applies …" "linearly precoding…": applying a linear transformation that transforms a block of input symbols into a block of output symbols in which each output symbol is a linear combination, or weighted sum, of input symbols.

The parties agree that these terms require the application of a linear transformation that combines multiple symbols and conforms to the two recited mathematical properties. Beyond these aspects in common, Defendants' construction is consistent with the claim language and intrinsic record, while Plaintiff's proposal improperly (1) reads out the claim requirement that the linear transformation be applied to "the constellation symbols," (2) expands the scope of the claims to cover non-linear transformations, even though the claims require the transformation to be linear, and (3) excludes embodiments in the specification by carving out spreading sequences. *See Phillips v. AWH Corp.*, 415 F.3d 1303, 1316 (Fed. Cir. 2005) (*en banc*) ("The construction that stays true to the claim language and most naturally aligns with the patent's description of the invention will be, in the end, the correct construction."); *Accent Packaging, Inc. v. Leggett & Platt, Inc.*, 707 F.3d 1318, 1326 (Fed. Cir. 2013) ("a claim interpretation that excludes a preferred embodiment from the scope of the claim is rarely, if ever, correct").

First, only Defendants' construction adheres to the claim requirement that the linear transformation be applied to "***the** constellation symbols*." More specifically, the claimed linear transformation must be applied to "the constellation symbols" that were output by the mapping unit. *See Wi-Lan, Inc. v. Apple, Inc.*, 811 F.3d 455, 462 (Fed. Cir. 2016) ("Subsequent use of the definite articles 'the' or 'said' in a claim refers back to the same term recited earlier in the claim. . . . The term 'the modulated data symbols' therefore refers back to the randomized data symbols produced by the computing means in the second claim element."). That the linear precoder's input must be the constellation

mapping unit's output is consistent with, and supported by, the specification and file history. *See* **'768** at 4:44-47; *see also* **'768** FH at 164 (Applicants explained that "***the input symbols provided to the precoder***" are "***the constellation symbols output by the constellation mapping unit***."); **VDW,** ¶71. Indeed, the parties otherwise agree that the components and method steps of these claims must be found/performed in the recited order. JCC at 4.

Nevertheless, Plaintiff's proposal attempts to enlarge the scope of the claims and allow the linear transformation to be applied to ***any*** "block of input symbols." This could be *any* arbitrary input, including symbols *other than* the output of the constellation mapping unit. Plaintiff's proposal, therefore, eviscerates the claims' express requirement that the linear transformation be applied to "*the* constellation symbols," and changes the plain meaning of the claim. *See W.E. Hall Co., Inc. v. Atlanta Corrugating, LLC*, 370 F.3d 1343, 1353 (Fed. Cir. 2004) ("Claim construction begins and ends in all cases with the actual words of the claim").

Second, although the parties seemingly agree that the claims require the application of a ***linear*** transformation, only Defendants' construction actually requires the transformation to be linear. For instance, because Plaintiff's proposal would cover applying a linear transformation to *any* "block of input symbols," Plaintiff would allow the output of the constellation mapping unit to be put through a ***non-linear*** transformation before being fed to the linear transformation. But the combination of a non-linear operation with a linear operation can be, collectively, ***a non-linear operation***,

such that the combined transformation applied to "the constellation symbols" might be non-linear—contrary to the plain language of the claims. **VDW,** ¶72. Further, Plaintiff's proposal fails because it seeks to allow the output symbols resulting from the "linear transformation" to be a "linear combination ***or weighted sum***" of input symbols. A "weighted sum" is *not* always a linear transformation. Weighted sums can be non-linear, such as in the case of a "weighted sum of squares" operation.[2] **VDW,** ¶73. Other examples of non-linear transformations that could be combined with a linear transformation to create a "weighted sum" include taking the logarithm or taking the real and imaginary part of a complex value. *Id.* By encompassing non-linear transformations, Plaintiff's proposal contradicts the plain language of the claims and should be rejected. *See W.E. Hall*, 370 F.3d at 1353.

Third, Plaintiff carves out spreading sequences from its construction of "linear transformation," but this runs counter to the plain meaning of the term. **VDW,** ¶74. For example, a POSITA would know that multiplication by Hadamard matrices (which are composed of spreading sequences called Walsh sequences) satisfies the two properties of a linear transformation that both parties agree upon—f(a+b)=f(a)+f(b), and kf(a)=f(ka). **VDW**, ¶75-78. Accordingly, a POSITA would not understand the plain meaning of "linear transformation" to exclude spreading sequences. Further, at least one embodiment of the linear transformation in the intrinsic record is a spreading matrix. *See*

[2] As described by NIST, this comprises squaring the input (a non-linear transformation) and then combining the squares (a linear transformation). *See* **VDW,** ¶73. As a whole, this transformation is non-linear. *Id.*

VDW, ¶78. The '933 provisional, incorporated by reference into the '768 patent at 1:5-12, repeatedly describes spreading sequences as being embodiments of the claimed precoders. *See, e.g.*, '933 provisional at 6 n.1 ("***[t]he spreading matrix C can be viewed (and will be invariably referred to) as a precoder….***" (emphasis added)), 38 (using a ***spreading sequence*** as a precoder), 70 (same); *see also* **VDW,** ¶78 (explaining that the spreading matrix described in the provisional application is a spreading sequence and the claimed precoder). Plaintiff's carve-out thus runs counter to the plain meaning, flies in the face of the intrinsic record, and should be rejected. *See W.E. Hall*, 370 F.3d at 13; *see also Phillips*, 415 F.3d at 1316.

In light of the arguments above, Plaintiff's only hope is to find some disavowal or disclaimer of claim scope. *Unwired Planet, LLC v. Apple Inc.*, 829 F.3d 1353, 1358 (Fed. Cir. 2016) ("A disclaimer or disavowal of claim scope must be clear and unmistakable, requiring "words or expressions of manifest exclusion or restriction" in the intrinsic record."). But there is no such disavowal. In fact, as discussed above, the specification includes an embodiment using spreading sequences as a precoder. **VDW**, ¶78. Nothing in the specification even hints at a disavowal, let alone satisfies the "clear and unmistakable" standard.

Neither is there prosecution history disclaimer. *See Omega Engineering, Inc, v. Raytek Corp.*, 334 F.3d 1314, 1325–26 (Fed. Cir. 2003) ("[F]or prosecution disclaimer to attach, our precedent requires that the alleged disavowing actions or statements made during prosecution be both clear and unmistakable."). Plaintiff's proposal presumably

relies on statements Applicants made about "spreading" to distinguish certain *draft* claims from a prior art reference. *See, e.g.*, '768 FH at 86-87. But these statements are not disclaimers at least because the draft claims did not even include the "linear transformation" term at the time. '768 FH at 76. Further, these statements are anything but "clear and unmistakable" at least because the Examiner could not make heads or tails of the claims at the time. The Examiner described the then-pending claims as "repugnant" and "mangled" and insisted that Applicants "draft[] complete claims comprehensible by one capable of understanding the subject matter" before he would reconsider his rejections. '768 FH at 106, 108.

With no disavowal or cognizable disclaimer, Plaintiff's construction is an unjustified carve-out from the ordinary meaning of "linear transformation," and should be rejected. *See Phillips*, 415 F.3d at 1316.

B. "interleaved data stream" ('768 cls. 1, 13 and 21) / "a symbol interleaver to process the precoded [symbols/data stream] to produce permuted blocks of the precoded symbols" ('768 cls. 1, 13) / "processing the [sic: precoded] symbols to produce permuted blocks of [sic: precoded] symbols" ('768 cl. 21) / "a deinterleaver that reassembles blocks of linearly precoded symbols from the demodulated data stream" ('768 cl. 8) / "an interleaver that interleaves the encoded symbols to produce interleaved symbols" ('230 cl. 1) / "interleaving the coded bits to produce interleaved bits" ('230 cl. 49) / "interleaving the coded symbols to produce interleaved symbols" ('230 cls. 13 and 16)

Defendants	Plaintiff
interleaved data stream: "bits that are the same as the bits of the encoded data stream that have been reordered so that adjacent bits are separated"	**interleaved data stream:** a data stream that is generated using an interleaver, which is an electronic circuit or computer implemented algorithm that takes an ordered set of values and reorders them"

a symbol interleaver to process the precoded [symbols/data stream] to produce permuted blocks of the precoded symbols: "an electronic circuit or computer-implemented algorithm that takes the precoded symbols and reorders them to separate adjacent symbols"	**a symbol interleaver to process the precoded [symbols/data stream] to produce permuted blocks of the precoded symbols:** "an electronic circuit or computer-implemented algorithm that takes an ordered set of precoded symbols and reorders them."
processing the [sic: precoded] symbols to produce permuted blocks of [sic: precoded] symbols: "taking the precoded symbols and reordering them to separate adjacent symbols"	**processing the [sic: precoded] symbols to produce permuted blocks of [sic: precoded] symbols:** "processing an ordered set of precoded symbols and reordering them"
a deinterleaver that reassembles blocks of linearly precoded symbols from the demodulated data stream: "an electronic circuit or computer-implemented algorithm that takes the demodulated data stream and reassembles blocks of linearly precoded symbols that had been reordered to separate adjacent symbols"	**a deinterleaver that reassembles blocks of linearly precoded symbols from the demodulated data stream:** "an electronic circuit or computer implemented algorithm that rearranges received demodulated data values corresponding to transmitted precoded symbols to reverse an interleaving step applied to the precoded symbols"
an interleaver that interleaves the encoded symbols to produce interleaved symbols: "an electronic circuit or computer-implemented algorithm that takes the encoded symbols and reorders them to separate adjacent symbols"	**an interleaver that interleaves the encoded symbols to produce interleaved symbols:** "an electronic circuit or computer-implemented algorithm that takes an ordered set of encoded symbols and reorders them"
interleaving the coded bits to produce interleaved bits: "taking the coded bits and reordering them to separate adjacent bits"	**interleaving the coded bits to produce interleaved bits:** "taking an ordered set of coded symbols and reordering them"
interleaving the coded symbols to produce interleaved symbols: "taking the coded symbols and reordering them to separate adjacent symbols"	**interleaving the coded symbols to produce interleaved symbols:** "taking an ordered set of coded bits and reordering them"

The dispute as to these terms primarily centers on what constitutes interleaving. In particular, as compelled by the intrinsic evidence and understanding of a POSITA, Defendants' constructions require that the bits or symbols be reordered so that adjacent bits or symbols are separated.[3] By contrast, Plaintiff's proposals are overly broad because they improperly encompass any form of reordering, including reordering that does not separate adjacent symbols, which is the fundamental reason for interleaving.

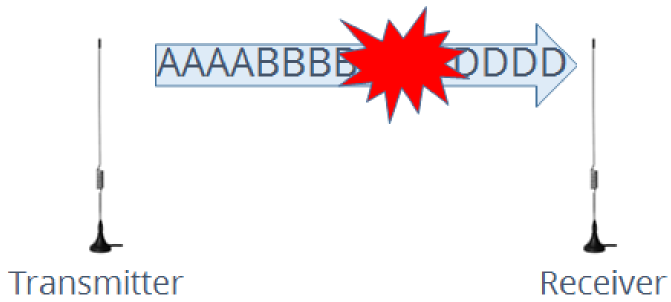
The well understood purpose of interleaving is to separate adjacent bits. By way of background, interleaving is a fundamental concept in communication systems. **VDW,** ¶39-43. "Interleaving" spreads apart adjacent bits or symbols to make it easier for the receiver to reconstruct received data. *Id.* The '768 and '230 patents describe two forms of interleaving. *Id.*; **'768** at Fig. 1, 4:22-60; **'230** at Fig. 12; CoC at 7. One form of interleaving spreads bits or symbols apart ***in time***, to avoid burst errors. **VDW,** ¶40. The other form spreads symbols ***in frequency***, to avoid interference that affects adjacent symbols. *Id.* The claims encompass both interleaving in time (e.g., '768 cls. 1, 13, and 21; '230 cls. 1 and 49) and in frequency (e.g., '768 cls. 1, 13, and 21), however the fundamental concept that bits/symbols adjacent in time or frequency be separated to avoid errors remains constant.

---

[3] Although the parties appear to agree that the value of the interleaved bits or symbols after interleaving must remain the same, Plaintiff's proposed constructions also do not address this critical property distinguishing interleaving from other operations such as scrambling.

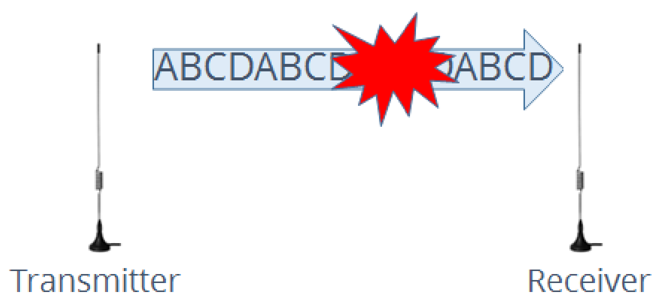
Taking interleaving in time as an example—as noted, it is done to avoid so-called "burst errors." A burst error occurs when short-term interference (e.g., noise) destroys part of a signal before it reaches the receiver. **VDW,** ¶40. The loss of several bits is called a burst. *Id.* Because a burst affects several adjacent bits, it makes it unlikely that the signal will be received properly. *Id.*; Baltersee at 2358. Interleaving solves this problem by ***requiring*** the separation of every adjacent bit or symbol of the input stream. For example, the Newton's reference, which Plaintiff cited as extrinsic evidence in connection with these terms (JCC, Ex. A at 2-3), confirms Defendants' constructions by stating that "[i]n the interleaving process, ***code symbols are reordered before transmission in such a manner that any two successive code symbols are separated*** . . . in the transmitted sequence . . . ." Newton's at 415 (emphasis added); *see also* Data & Telecommunications Dictionary at 395 (interleaving for data transmission means "code symbols are arranged in an interleaved pattern before transmission and reassembled upon receipt").

By way of illustration using letters in place of bits or symbols, if the four letters "ABCD" are sought to be transmitted, redundancy could be added to the message—*e.g.*, making it "AAAABBBBCCCCDDDD"—to help ensure that each letter reaches the receiver properly. However, a burst error could cause all transmissions of a letter to be lost, as with the letter "C" in this example:



VDW, ¶40.

Interleaving over time can solve this burst problem. **VDW,** ¶81-82. The purpose of such interleaving is to "transform[] [a] bursty channel into an independently distributed channel." Baltersee at 2358; **VDW,** ¶83. That is, interleaving distributes adjacent bits or symbols across the channel in time so that if a burst occurs, previously adjacent bits or symbols will not be lost to the burst. *Id.* For example, in the prior illustration, when interleaving the letters by separating adjacent letters—*e.g.*, "ABCDABCDABCDABCD"—a single burst error does not prevent the receipt of the letter "C," as illustrated as follows:



Id.

As a result, consistent with the Newton's reference, interleaving over time ***must*** separate adjacent bits or symbols. **VDW,** ¶82-83. If it did not, the purpose behind these claims' calling for interleaving the data stream, symbols, or bits—avoiding burst errors—

would be lost. *See AIA Eng'g Ltd. v. Magotteaux Int'l S/A*, 657 F.3d 1264, 1278 (Fed. Cir. 2011) (holding that "a construction that renders the claimed invention inoperable should be viewed with extreme skepticism").

By contrast, Plaintiff's proposals are overly broad because mere "reorder[ing]" of bits does not guarantee that they are separated. For example, in the illustration above, Plaintiff's proposals would encompass an algorithm that simply reverses the message to read "DDDDCCCCBBBBAAAA." **VDW,** ¶84. The reversed message "DDDDCCCCBBBBAAAA" would be no less vulnerable to burst errors than the original message "AAAABBBBCCCCDDDD." *Id.* As shown in the following illustration, a single burst error could still destroy every transmission of the letter B, as was the case for the original message as explained above:

Id. Thus, a POSITA would not consider Plaintiff's proposals to be "interleaving," because it would eviscerate the very purpose behind interleaving in time. **VDW,** ¶85.

Likewise, the technical rationale behind the interleaving in frequency is to separate adjacent bits/symbols to mitigate the effects of interference on adjacent frequencies. **VDW,** ¶42-43. For reasons analogous to the separation of adjacent symbols over time as

described above, the interleaver must separate adjacent symbols across frequencies in order to constitute interleaving. **VDW,** ¶80-85. That is, adjacent symbols must be separated so groups of symbols are not lost. *Id.* Plaintiff's proposal fails because it merely calls for "reordering," and thus does not ensure any separation at all.

Besides this key distinction, the parties' "symbol interleaver" and "de-interleaver" constructions include one more important difference. As with "the constellation symbols" in Section II.A, Plaintiff's proposal improperly reads out the claim requirement that the symbol interleaver process "***the*** precoded symbols"—*i.e.*, the symbols generated by the claimed precoder. Instead, Plaintiff's proposal calls for operating on "***an*** ordered set of precoded symbols." Plaintiff's use of "an" would allow for ***any*** ordered set of precoded symbols to be interleaved, whereas Defendants' construction remains faithful to the claim language by limiting the processing to "the precoded symbols." *See Wi-Lan*, 811 F.3d at 462 ("Subsequent use of the definite articles "the" or "said" in a claim refers back to the same term recited earlier in the claim.").

C. "applying/applies a linear transformation to a/the stream of information bearing symbols" ('230 cls. 1, 16, 49, 64, 68)

Defendants	Plaintiff
"applies/applying a time invariant linear transformation to the stream of information bearing symbols by combining two or more of the information bearing symbols with each other to produce precoded symbols, wherein the linear transformation has the following properties: 1) For any constellation symbols a and b, f(a + b) = f(a) + f(b) 2) For any scalar k, f(k*a) = k*f(a)"	"transforms/transforming blocks of symbols from the stream of information bearing symbols using a linear transformation to produce symbols that linear combinations, or weighted sums, of the information bearing symbols." "linear transformation": *see* proposed construction for the '768 patent

While the parties' constructions for these terms have several differences, one difference is critical: Defendants' construction reflects the clear and unequivocal disclaimer in the specification of the '230 patent that the claimed linear transformation must be ***time invariant***. *See* **'230** at 5:25-30. Plaintiff's proposal, by contrast, ignores this disclaimer—allowing the transformation to be time-varying—and is therefore impermissibly broad. The Federal Circuit has held that "[w]here the specification makes clear that the invention does not include a particular feature, that feature is deemed to be outside the reach of the claims of the patent, even though the language of the claims, read without reference to the specification, might be considered broad enough to encompass the feature in question." *SciMed Life Sys. v. Adv. Cardiovascular Sys.*, 242 F.3d 1337, 1341 (Fed. Cir. 2001).

As background, a transformation is "time invariant" if the transformation does not vary as a function of time. **VDW,** ¶93. For example, the linear transformation $y(x) = 2 \times x$ is time invariant because, at all times, y will equal $2 \times x$. *Id.* By contrast, the linear transformation $y(x) = 2 \times x \times t$, where t is an indication of time (*e.g.*, in minutes), varies with time based on the variable t and is therefore "time varying." *Id.*

In the '230 patent, Applicants clearly and unequivocally declared that the linear transformations in the claimed invention, signified by the Greek letter Θ, ***excludes*** time-varying linear transformations:

> The encoder Θ considered here does not depend on the OFDM symbol index i. ***Time-varying encoder may be useful for certain purposes***, (e.g., power loading)***, but they will not be pursued here.*** Hence, from now on, we will drop our OFDM symbol index i for brevity.

'230 at 5:25-30 (emphasis added); *see also* CoC at 9; **VDW,** ¶94. The specification is unambiguous: time-varying encoders "will not be pursued here," and as a result, the OFDM symbol index "i" will no longer appear in the specification because it is not needed. Thus, the claimed linear transformation must be time invariant.

The remainder of the '230 patent confirms this disclaimer, repeatedly and consistently describing only time-invariant linear transformations. The matrix Θ is referenced more than 80 times after the disclaimer, and not once does it include the time variable index "i" when represented as an equation, or otherwise indicate that Θ can vary over time. **VDW,** ¶95. *See In re Abbott Diabetes Care Inc.*, 696 F.3d 1142, 1149 (Fed. Cir. 2012) ("[E]very embodiment disclosed in the specification shows an electrochemical sensor without external cables or wires…. In the case before us, however, nothing

suggests or even hints that the claimed electrochemical sensor can include external cables or wires. Instead, Abbott's patents consistently show the opposite."). Only Defendants' construction properly reflects this time-invariance disclaimer, and should be adopted.

There are other differences between the parties' constructions for these terms, but they primarily relate to the meaning of "linear transformation." With respect to these differences, Defendants' arguments in Section II.A apply equally here. Furthermore, to the extent Plaintiff relies on any alleged disclaimer in the prosecution history of the '768 patent to carve out spreading sequences from the "linear transformation" term here, such alleged disclaimer should not apply to the '230 patent. The two patents are *not* related—they have different inventors, different specifications, and did not result from the same underlying patent application. *Abbott Laboratories v. Dey, L.P.*, 287 F.3d 1097, 1105 (Fed. Cir. 2002) ("[W]e do not see a basis for concluding that statements made about the [claims in one patent] should be attributed to the [claims in the construed] patent, simply because the applications had a common assignee, one common inventor, and similar subject matter" where the construed patent "was not filed as a continuation, continuation-in-part, or divisional application of the [other patent]."). The fact that the patents were filed on the same day and claim priority to the same provisional applications is irrelevant and does not create a relationship. *Id.*; *see also In re Berg*, 140 F.3d 1428, 1435 n. 7 (Fed. Cir. 1998) ("[E]ach application is independent and patentably distinct" where they are "not related as by continuation, continuation-in-part, or divisional."). The Court should

thus reject Plaintiff's attempt to import an alleged disclaimer from the unrelated '768 patent prosecution to this '230 patent term.

D. "[wherein the] linear transformation is based on multiple matrices…[]" ('230 cls. 30, 33, 64, 68) / "wherein the linear transformation is based on $\Theta = F_{N_t}^T \mathrm{diag}(1, \alpha, \ldots, \alpha^{N_t - 1})$, $\alpha := e^{j2\pi/P}$" ('230 cls. 41, 66, 70)

Claim Limitation	Defendants	Plaintiff
"[wherein the] linear transformation is based on multiple matrices [comprising]…[]"	Indefinite.	"The linear transformation can be described as multiplication by a matrix that is the product of at least two other matrices"
"wherein the linear transformation is based on: $\Theta = F_{N_t}^T \mathrm{diag}(1, \alpha, \ldots, \alpha^{N_t - 1})$, $\alpha := e^{j2\pi/P}$"	Indefinite.	The linear transformation includes a mathematical operation that can be described as multiplication by the matrix Θ as specified in the claim.

These limitations are indefinite because the claims recite that the linear transformation is "***based on***" the claimed "multiple matrices"[4] or matrix "Θ," and it is not clear whether the claims are practiced only when the claimed matrices are used or if some degree of variation from the claimed matrices is permitted.

A claim must provide "clear notice of what is claimed, thereby apprising the public of what is still open to them." *Nautilus, Inc. v. Biosig Instruments, Inc.*, 134 S. Ct. 2120, 2129 (2014). The Supreme Court has held that "claims, viewed in light of the

4 For example, Claim 30 includes "a fast Fourier matrix" and "a diagonal matrix."

specification and prosecution history, [must] inform those skilled in the art about the scope of the invention with reasonable certainty." *Id.*; *see also Interval Licensing LLC v. AOL, Inc.*, 766 F.3d 1364, 1370 (Fed. Cir. 2014). A claim, "read in light of the specification and the prosecution history, must provide objective boundaries for those of skill in the art." *Interval*, 766 F.3d at 1371. Merely identifying "*some standard* for measuring the scope of the phrase" is insufficient. *Id.* at 1370-71 (emphasis in original).

In this case, a POSITA cannot determine with reasonable certainty whether a particular linear transformation is "based on" the "multiple matrices" or matrix "Θ." **VDW,** ¶98. Neither the claims nor the intrinsic record provides any objective standard for determining how much deviation from these matrices is allowed. The specification sets forth one example of the claimed linear transformation, but this example does not provide an objective boundary because it specifies the linear transformation to be Θ itself. *See* CoC, 6; **VDW,** ¶99-100. Additionally, a POSITA would not know what it means for a linear transformation to be "based on" these matrices. **VDW,** ¶99-100.

For example, claim 41 of the '230 patent requires that the precoder apply a linear transformation "based on" matrix Θ, as follows:

> *41. The method of claim 40, wherein the number of the antennas is represented by N_t, wherein the first matrix is based on an N_t-point inverse version of the FFT matrix, wherein the linear transformation is based on:*
>
> $$\Theta = F_{N_t}^{T} \operatorname{diag}(1, \alpha, \ldots, \alpha^{N_t-1}), \alpha := e^{j2\pi/P}$$
>
> *wherein $F_{N_t}^{T}$ represents the first matrix, and wherein $diag(1, \alpha, \ldots, \alpha^{N_t-1})$ represents the second matrix, wherein P is an integer.*

(highlighting added). This equation specifies a linear transformation Θ using a particular variable, α, which is defined as $\alpha := e^{j2\pi/P}$. **VDW,** ¶99. A POSITA would not be able to determine with reasonable certainty whether α can differ from the claimed equation and still fall within the scope of the claim. *Id*. For example, α could be modified so that there is an 8 in the exponent instead of a 2, and it is not clear if a linear transformation applying such an equation would fall within the scope of the claims. *Id*. The claimed Θ also specifies that the first matrix must be the transpose of an FFT matrix, as denoted by the superscript "T" in F_{Nt}^{T}. *Id*. A POSITA would not be able to determine with reasonable certainty whether a linear transformation applying an equation that implemented an FFT matrix that is not a transpose is "based on" Θ. *Id*.

Plaintiff's proposals, which define "based on" as "***includes*** a mathematical operation that ***can be described as*** multiplication by the matrix Θ," find no support in the '230 patent. Plaintiff simply replaces one indefinite term, "based on," with another, "can be described as." The specification provides no objective standard for determining

whether an operation "can be described as" the multiplication specified in Plaintiff's proposals, nor could a POSITA make such a determination with reasonable certainty. **VDW, ¶**100. If Plaintiff's construction were adopted, it would still not be clear how similar an operation must be to the specified multiplication to be permissibly "described" as such. *Id.* Thus, the claims would remain indefinite even under Plaintiff's proposals. *See Interval*, 766 F.3d at 1371 ("Even if a claim term's definition can be reduced to words, the claim is still indefinite if a person of ordinary skill in the art cannot translate the definition into meaningfully precise claim scope.").

E. "wherein the first matrix is based on a fast Fourier transform (FFT) matrix, and wherein the second matrix is based on a diagonal matrix" ('230 cls. 30, 64, 68) / "wherein the first matrix is a matrix of size $N_t x N_t$… wherein the second matrix is a diagonal matrix" ('230 cls. 33, 43)

Claim Limitation	Defendants	Plaintiff
"wherein the first matrix is based on a fast Fourier transform (FFT) matrix, and wherein the second matrix is based on a diagonal matrix" [cls. 30, 64, 68]	The term "based on" is indefinite. Should the court find this term to not be indefinite, the linear transformation must be represented in the following order: [FFT matrix]* [Diagonal matrix]	Ordinary meaning
"wherein the first matrix is a matrix of size $N_t x N_t$… wherein the second matrix is a diagonal matrix" [cls. 33, 43]	The term "based on" in the prior limitation of this claim is indefinite. Should the court find this term to not be indefinite, the linear transformation must be represented in the following order: [first	The first matrix is a matrix with Nt rows and Nt columns, where Nt is the number of transmit antennas in the transmitter. The second matrix is a diagonal matrix.

	matrix of size N_t rows by N_t columns, wherein each entry of the first matrix is based on a power of $e^{j2\pi/Nt}$, each entry of a column of the first matrix being equal to one,]*[second matrix that is a diagonal matrix of size $N_t x N_t$ having diagonal entries that are based respectively on different powers of $e^{j2\pi/p}$ including the zeroth power, wherein P is a positive integer]	

1. <u>The first limitation above is indefinite.</u>

The limitation "wherein the first matrix is based on a fast Fourier transform (FFT) matrix, and wherein the second matrix is based on a diagonal matrix," is indefinite for the same reason that the previous term is indefinite. Neither the claims nor the intrinsic record inform one skilled in the art what it means for one matrix to be "based on" another matrix. *See id.*; **VDW**, ¶101.

For instance, a "diagonal matrix" is "a matrix having non-zero values only on the diagonal" (JCC at 3), such as the following:

$$\begin{matrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{matrix}$$

VDW, ¶102. Without any objective standard in the claims or specification, a POSITA would not be able to determine with reasonable certainty the degree to which a matrix can differ from this diagonal matrix and still be "based on" it. *Id.* For example, a

POSITA would not know with reasonable certainty whether the following non-diagonal matrix, which adds one non-zero value outside the diagonal, falls within the scope of the claim:

$$\begin{matrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 1 & 0 & 1 \end{matrix}$$

VDW, ¶103. Alternatively, a POSITA would not know whether a "tridiagonal matrix," which is a matrix that has nonzero elements on the main diagonal, as well as on the diagonals above and below the main diagonal, falls within the scope of the claim:

$$\begin{matrix} 1 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 1 \end{matrix}$$

Id. The specification does not provide an objective standard for determining whether these other matrices are "based on" a diagonal matrix. **VDW,** ¶104. As a result, this limitation renders the claims indefinite. *See Interval*, 766 F.3d at 1371.

2. <u>If the Court does not find these terms indefinite, the matrices must be multiplied in the recited order.</u>

If the Court determines these claims are not indefinite, there would be no dispute that the recited "linear transformation" in these claims is represented by multiplying together the claimed "first" and "second" matrices. The parties disagree as to the required *ordering* of the matrices in this multiplication. Only Defendants' construction recites the intended ordering.

Matrix multiplication is not commutative; in other words, the product of two matrices is dependent upon the order in which the matrices are multiplied. **VDW**, ¶105. Thus, A*B (A times B) does not necessarily equal B*A (B times A). *Id.*

To one skilled in the art, a mathematical expression is read from left to right. **VDW,** ¶106. If a mathematical expression includes matrices identified as the "first" and "second," one skilled in the art would have understood that the "first" matrix appears first (on the left) and the "second" matrix appears second (on the right). *Id*. This understanding is important, since reversing the order of matrices in a multiplication may provide a different result. *Id*.

Under the plain meaning of the claims, the multiplication must be carried out in the following order: ["first matrix"] * ["second matrix"]. **VDW,** ¶105-106. Defendants' constructions reflect this ordering, whereas Plaintiff's proposals do not.[5] *Id.*

This understanding is confirmed by the intrinsic record. The intrinsic record's only disclosure of the matrix multiplication in these limitations places the "first matrix" (the FFT matrix or matrix of size $N_t x N_t$) on the left and the "second matrix" (the diagonal matrix) on the right, as follows:

$$\Theta = \overset{\text{“First”}}{\boxed{\mathbf{F}_{N_t}^T}} \overset{\text{“Second”}}{\boxed{\operatorname{diag}(1, \alpha, \ldots, \alpha^{N_t - 1})}}, \qquad \alpha := e^{j2\pi/P}$$

[5] Defendants' construction for the transformation in claim 33, while appearing lengthy, simply substitutes in the actual claim language for the recited "first" and "second" matrices directly from the claim itself.

See Provisional App. No. 60/374,935 at 47 (annotated), 59 (same); CoC at 6 (same); **VDW,** ¶107; Plaintiff's Interrog. Responses, Ex. B at 33, 37, 69, 103, 109 (admitting that this equation is the only support for the first limitation above). Defendants' ordering is further confirmed by claims 41, 66, and 70 of the '230 patent, which depend on claims 40, 64, and 68 at issue here. These claims set forth the same equation for Θ and refer to $F_{N_t}^T$, situated on the left side of the multiplication, as the "first" matrix and *diag*(1, α,…, α^{N_t-1}), situated on the right side of the multiplication, as the "second" matrix.

F. "applying a unitary matrix" ('230 cls. 3, 46, 56)

Defendants	Plaintiff
"performing a mathematical operation that, when expressed in its matrix form, is multiplication by a unitary matrix"	"performing a mathematical operation that, when expressed in matrix form, includes multiplication with at least a unitary matrix"

First, Plaintiff's proposal improperly imports "at least" into its construction based on the word "comprises" found elsewhere in the claims. But the word "comprises" is not present in the term being construed. So in claim 3, where "comprises" is nowhere to be found, Plaintiff's proposal improperly converts a closed-ended limitation into an open-ended one. The "comprising" in claim 1's preamble is irrelevant. *See Dippin' Dots, Inc. v. Mosey*, 476 F.3d 1337, 1343 (Fed. Cir. 2007) ("The presumption raised by the term 'comprising' does not reach into each of the six steps to render every word and phrase therein open-ended—especially where, as here, the patentee has narrowly defined the claim term it now seeks to have broadened."). On the other hand, in claims 18, 46, and

56, where "comprises" immediately precedes the term, adding "at least" to this term's construction renders the word "comprises" superfluous. *See Digital-Vending Servs. Int'l v. The Univ. of Phoenix, Inc.*, 672 F.3d 1270, 1275 (Fed. Cir. 2012).

Second, Plaintiff's proposal is overly broad because virtually ***any*** mathematical operation can be manipulated to meet Plaintiff's definition. Consider the multiplication of two non-unitary matrices, A and B. One of ordinary skill in the art would recognize that this operation, AB, does not fall within the scope of "applying a unitary matrix." **VDW**, ¶109-110. And yet, AB could also be expressed in matrix form as $ABUU^*$ (which equals ABI, which equals AB).[6] *Id.* Indeed, Plaintiff's proposal would allow virtually any operation to be expressed in a way that meets the construction—just add UU^* to the expression. *Id*. Plaintiff's proposal fails because it renders the limitation meaningless. *See also Bicon, Inc. v. Straumann Co.*, 441 F.3d 945, 950-51 (Fed. Cir. 2006) ("When the language of a claim is clear, as here, and a different interpretation would render meaningless express claim limitations, we do not resort to speculative interpretation based on claims not granted.").

Defendants' construction, by contrast, differs from Plaintiff's proposal by including "its" and not including "at least." This clarifies that the actual algorithm must, when written in its matrix form, be multiplication by a unitary matrix. **VDW**, ¶111. It is

[6] A "unitary matrix" is "a square matrix whose conjugate transpose is equal to its inverse." JCC at 3. For any unitary matrix U, multiplying U by its conjugate transpose, U^*, yields the identity matrix, I. **VDW**, ¶110. That is, $UU^* = I$. *Id.* A matrix multiplied by the identity matrix is itself—i.e., for a matrix A, $AI = A$. *Id.*

undisputed that it is proper to express a mathematical operation in "its matrix form," since Plaintiff agreed to such a construction for the term "linear precoder comprises a unitary matrix." JCC at 3. And referring to the example above, Defendants' construction makes clear that *AB* cannot be arbitrarily manipulated to *ABUU** to satisfy the limitation. *Id.* Defendants' construction is consistent with a POSITA's understanding. *Id.*

G. "a diagonal matrix to phase-rotate each entry of a symbol vector" ('230 cls. 30, 64, 68)

Defendants	Plaintiff
Indefinite	"a diagonal matrix that applies a set of phase offsets to the entries of a symbol vector, such as diag1, α, …, αNt-1, to modify the phase of at least some of those symbols"

This term is indefinite because the patent specification and claims are internally inconsistent, and/or conflict with the prior art and a POSITA's understanding without any sufficient explanation. The term fails to inform the scope of the invention with reasonable certainty as a result. *See Nautilus, Inc. v. Biosig Instruments, Inc.*, 134 S. Ct. 2120, 2129 (2014) ("Claims, viewed in light of the specification and prosecution history, [must] inform those skilled in the art about the scope of the invention with reasonable certainty."); *see also In re Moore,* 439 F.2d 1232, 1235-36, 169 USPQ 236, 239 (CCPA 1971) (explaining that a claim that is clear on its face may be indefinite when a conflict or inconsistency between the claimed subject matter and the specification disclosure or

prior art teachings renders the scope of the claim uncertain.) Plaintiff's attempted rewrite of the term only further confirms that the claims are broken as written.

As background, a "diagonal matrix" is a matrix that has non-zero values only along the diagonal from upper-left to lower-right, as in this example:

$$\begin{matrix} A & 0 & 0 \\ 0 & B & 0 \\ 0 & 0 & C \end{matrix}$$

In this example, the diagonal consists of variables A, B, and C, and the matrix can be expressed as *diag(A,B,C)*. **VDW,** ¶112. Multiplying a diagonal matrix by a vector multiplies each of the terms of the vector by the corresponding diagonal entry. *Id***.** Thus, multiplying *diag(A,B,C)* by vector $\begin{bmatrix} x \\ y \\ z \end{bmatrix}$ yields vector $\begin{bmatrix} Ax \\ By \\ Cz \end{bmatrix}$. *Id***.**

The term at issue, present in claims 30, 64, and 68, calls for "a diagonal matrix to phase-rotate *each entry* of a symbol vector." Thus, according to the plain language of the claims, *each value* in the diagonal must apply a phase-rotation to its corresponding entry of the symbol vector. **VDW,** ¶115. But the inherent problem with these claims is that the specification's only example "diagonal matrix to phase-rotate *each* entry"—which is the same matrix found in claims that depend from 30, 64, and 68—includes a "1" entry along the diagonal, and multiplying by a "1" is commonly understood *not* to "phase-rotate" a corresponding symbol entry. **VDW,** ¶113-115.

To be clear, the parties and their experts seem to agree that a diagonal matrix with a "1" entry does not "phase-rotate each entry" of the symbol vector—and yet that is

exactly what the patent specification describes and the claims would require. **VDW,** ¶118. The claims are indefinite as a result. *See Trustees of Columbia University in the City of New York v. Symantec Corp.*, 811 F.3d 1359, 1367 (Fed. Cir. 2016) (affirming the indefiniteness of claims directed to extracting machine code instructions from something that did not have machine code instructions, and explaining, claims that are "nonsensical in the way a claim to extracting orange juice from apples would be" are indefinite.); **VDW,** ¶117.

Nothing in the intrinsic record does anything to explain away this inconsistency. In relevant part, the specification first discloses the "*diag*(1, α, …, α^{Nt-1})" matrix and then says that the "matrix amounts to phase-rotating each entry of the symbol vector." CoC at 6. The claims do this in reverse, first claiming a matrix that phase-rotates each entry, then claiming the specific "*diag*(1, α, …, α^{Nt-1})" matrix. *See* claims 30, 31. But the patent never ascribes any special meaning to the term "phase-rotate," much less explains how multiplication by "1" might "amount[] to phase-rotating" the corresponding entry of the symbol vector. Indeed, this limited disclosure is the only time that the terms "phase" and "phase-rotating" can be found within the entire patent specification and certificate of correction. **VDW,** ¶116.

Plaintiff's proposed construction implicitly acknowledges the patent's internal inconsistency. Plaintiff attempts to rewrite the term from a matrix that "phase-rotate[s] each entry of a symbol vector" to one that modifies the phase of "at least some" (but not all) of those entries. Central to Plaintiff's argument is the understanding that

multiplication by "1" is not a phase-rotation. But having made this concession, Plaintiff cannot now deny that the patent's "diagonal matrix" term and its only diagonal matrix example are internally inconsistent. The claims fail to inform the scope of the invention with reasonable certainty as a result.

On the other hand, if one were to argue that multiplication by "1" is a "phase-rotation" as the term is used in the patent, then it must be true that a diagonal matrix of all "1s", i.e., *diag*(1,1,…,1), satisfies the "matrix to phase-rotate each entry of a symbol vector" limitation. This follows from the plain language of the "each entry" term. And yet, such a construction would render the term "phase-rotate" a nullity, since ***any*** diagonal matrix would necessarily meet the limitation for the same reasons. **VDW,** ¶119; *see also Merck & Co., Inc. v. Teva Pharm. USA, Inc.*, 395 F.3d 1364, 1372 (Fed. Cir. 2005) ("A claim construction that gives meaning to all the terms of the claim is preferred over one that does not do so."); *Creative Internet Advertising Corp. v. Yahoo!, Inc.*, 476 Fed. Appx. 724, 728-29 (Fed. Cir. 2011) (rejecting proposed construction that would render claim term a "nullity").

Either way, the specification fails to provide an objective standard for determining what the patent means by "a diagonal matrix to phase-rotate each entry of a symbol vector." The claims are indefinite as a result. *See Interval*, 766 F.3d at 1371.

H. "subcarriers carry different linear combinations of the information symbols" ('230 cls. 2, 17)

Defendants	Plaintiff
"subcarriers carry different linear combinations of the stream of information symbols transformed by the second encoder"	"the different subcarriers carry different weighted sums of the stream of information symbols transformed by the second encoder"

The parties dispute whether the claim term "linear combination" should be replaced with the term "weighted sum." It should not. The term "weighted sum" does not appear anywhere in the '230 patent, and nothing in the intrinsic record supports the notion that "linear combination" is identical to "weighted sum." To the contrary, as discussed in Section II.A, the term "weighted sum" can encompass *non*-linear combinations. Plaintiff's proposed modification of "linear combinations" lacks any support in the intrinsic record and should be rejected. **VDW**, ¶120.

III. DISPUTED TERMS IN THE CFO PATENTS

A. "null subcarrier" (CFO Patents, all asserted claims)

Defendants	Plaintiff
"A subcarrier on which no value is intended to be transmitted during a specific time period, used to estimate carrier frequency offset"	"A subcarrier on which no value is intended to be transmitted during a specific time period"

There is no dispute that a "null subcarrier" is a subcarrier on which no value is intended to be transmitted during a specific time-period. Where the parties disagree is whether ***every time*** no value is transmitted that this constitutes a "null subcarrier," or

instead whether the specification uses the term "null subcarrier" exclusively to refer to estimations of carrier frequency offset. As explained below, the specification makes clear that null subcarriers are one particular class of zero symbols (where no value is transmitted) that the invention uses to estimate carrier frequency offset. The Court should therefore adopt Defendants' proposed construction and reject Plaintiff's overbroad proposal, which is inconsistent with the specification and the purpose of the invention.

Critically, the CFO Patents explain that there are at least ***two different types*** of zero symbol transmissions, but define only ***some*** of these zero symbols to be "null subcarriers." Specifically, the CFO Patents expressly distinguish (1) zero symbols used to remove interference from other channels and (2) zero symbols that serve as a null subcarrier:

> In each OFDM transmission block, there are four non-zero training symbols, 4 zero symbols to remove interference from other channels, and one zero symbol serving as a null subcarrier.

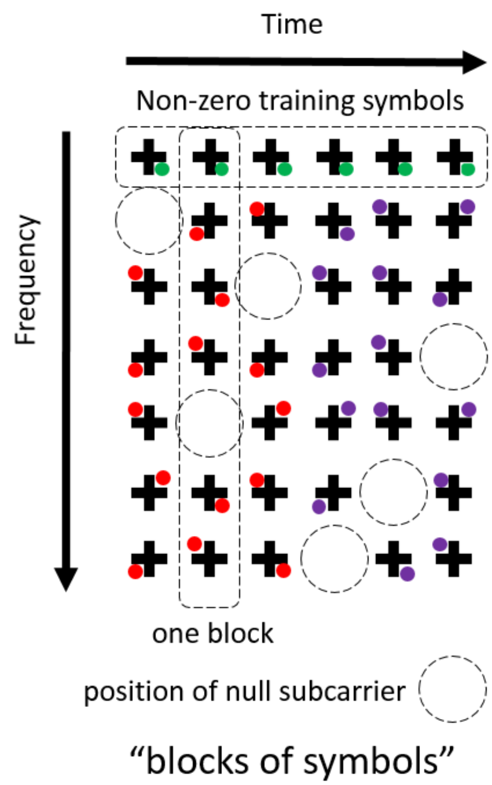
'317, 15:63-67.[7] Thus, the CFO Patents' description of "null subcarriers," which expressly ***excludes*** certain zero symbols, compels Defendants' construction. Plaintiff's proposal would improperly sweep every zero symbol into the definition of "null subcarrier."

---

[7] The CFO Patents further state that training symbols—which are expressly distinct from null subcarriers—"may include both non-zero symbols and zero symbols." **'317**, 2:27-28; *see also, e.g., id.* at cl. 1 (training symbols and null subcarriers are inserted separately, and are thus distinct).

Correctly recognizing that only *some* zero symbols are "null subcarriers," Defendants' construction properly states that null subcarriers are just those zero symbols that are used to estimate CFO. The only use described in the CFO patents for null subcarriers is performing CFO estimation, and the only way the CFO Patents describe performing CFO estimation is by using null subcarriers. *See, e.g.*, **'317,** 8:35-38 ("The null subcarrier is inserted so that the position of the null subcarrier hops from block to block and enables CFO estimation to be separated from MIMO channel estimation."); 2:30-36; 14:10-18; 10/850,961 FH, Response to 9/30/10 OA at 16 ("The 'hopping' of Applicant's claims, however, is based upon the insertion of null subcarriers at different positions within two or more individual blocks (*e.g.*, OFDM blocks), where carrier frequency offset estimation is performed based on the positions of these null subcarriers in the blocks.").

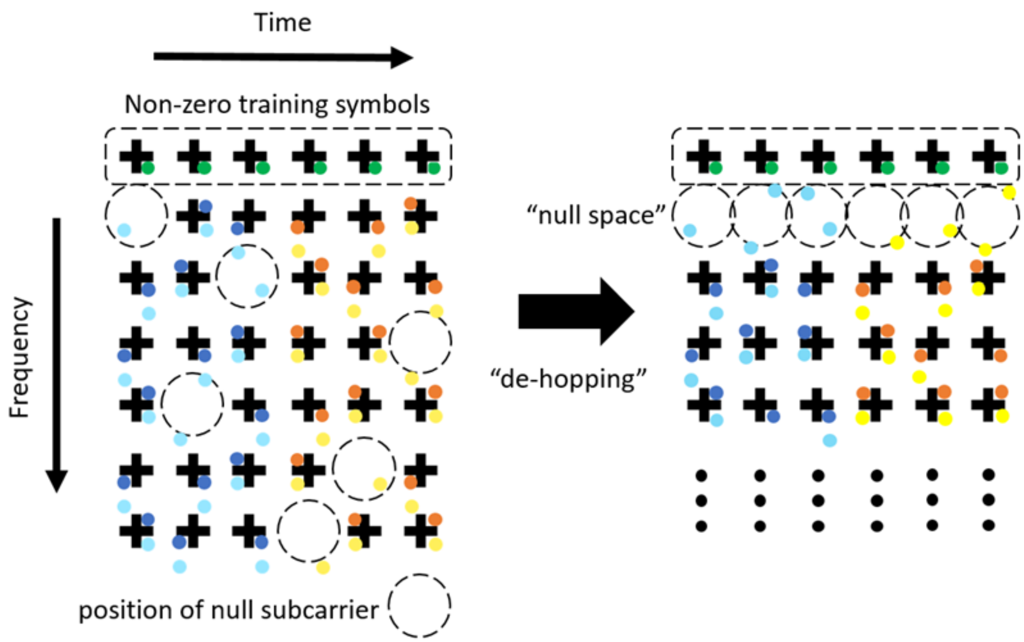
More specifically, the CFO Patents explain that null subcarriers are inserted at different positions in each block, in accordance with a hopping code. *Id.* at 2:30-36, 8:9-38; **VDW** ¶127. This is depicted in the example representation below, where the colored dots represent data values on subcarriers and the dashed circles represent the inserted null subcarriers (which have no data values) at the transmitter before transmission.



According to the CFO Patents, CFO causes these zero symbols to be received differently than how they were transmitted, where data values become "offset" from their intended frequency, including some data values being shifted into the frequencies of the null subcarriers. *Id*. at 9:37-38; **VDW** ¶¶127-128. The CFO Patents teach that the receiver "de-hops" the null subcarriers and estimates CFO based on measurement of any shift of data values into the null space, with the goal of minimizing a "cost function." *Id.* at 9:38-39; 10:27-28; 14:9-11.

This is depicted in another illustrative example below, this time representative of a transmission as received by a receiver after transmission. The left-hand figure includes lighter colored dots representing the "offset" of data values caused by CFO, including

offsets into the null subcarriers. The right-hand figure represents the realignment of the null subcarriers used for CFO by "de-hopping" to create a null space.



After the receiver estimates CFO, the null subcarriers are removed, and then channel estimation is performed. **'317**, 14:15-22, Fig. 4 (steps **60** and **62**); *see also* CFO Provisional, 3-4 ("To estimate the channels, we first take FFT of $\bar{y}_v(k)$ and then remove the null-subcarrier at the receiver….").

Thus, the CFO Patents describe not only using the null subcarriers for the purpose of estimating CFO, but also removing the null subcarriers after estimating CFO, confirming that they cannot be used for any other purpose. *See id.* Only Defendants' construction properly limits the construction for "null subcarrier" to the zero symbols that are used to estimate CFO. *See Phillips*, 415 F.3d at 1316 ("The construction that stays

true to the claim language and most naturally aligns with the patent's description of the invention will be, in the end, the correct construction.").

Indeed, if Plaintiff's proposal were adopted, the CFO Patents would not be able to fulfill their stated purpose. Plaintiff's proposal would allow infringement to be shown by the presence of *any* zero symbols that otherwise satisfy the claims, even if those zero symbols were not used to estimate CFO. Since the only technique described to estimate CFO is to use zero symbols that are "null subcarriers," allowing null subcarriers not to serve the purpose of estimating CFO would leave the claims without ***any*** way to allow estimation of CFO. **VDW**, ¶¶127-128. But as is made clear throughout the CFO Patents, allowing CFO (and channel) estimation is the very purpose of the claimed invention. *E.g.*, **'317**, 2:16-20 ("In general, <u>the invention is directed to techniques for carrier frequency offset (CFO) </u>and channel estimation of [OFDM] transmissions over [MIMO] frequency-selective fading channels."), 3:57-59 ("FIGS. 5-12 are graphs illustrating performance estimates of the CFO and channel estimation techniques described herein."); *see also, e.g.*, *id.* at Title, Abstract, 4:18-21. Under Plaintiff's proposal, the alleged invention would not be usable for its own alleged purpose. *See AIA Eng'g Ltd. v. Magotteaux Int'l S/A*, 657 F.3d 1264, 1278 (Fed. Cir. 2011) (holding that "a construction that renders the claimed invention inoperable should be viewed with extreme skepticism").

B. "subcarrier" (CFO Patents, all asserted claims) ('230 cls. 2, 17)[8]

Defendants	**Plaintiff**
"In a MIMO multi-carrier waveform, one of a number of carrier frequencies within a larger frequency band"	"In a multi-carrier waveform, one of a number of carrier frequencies within a larger frequency band"

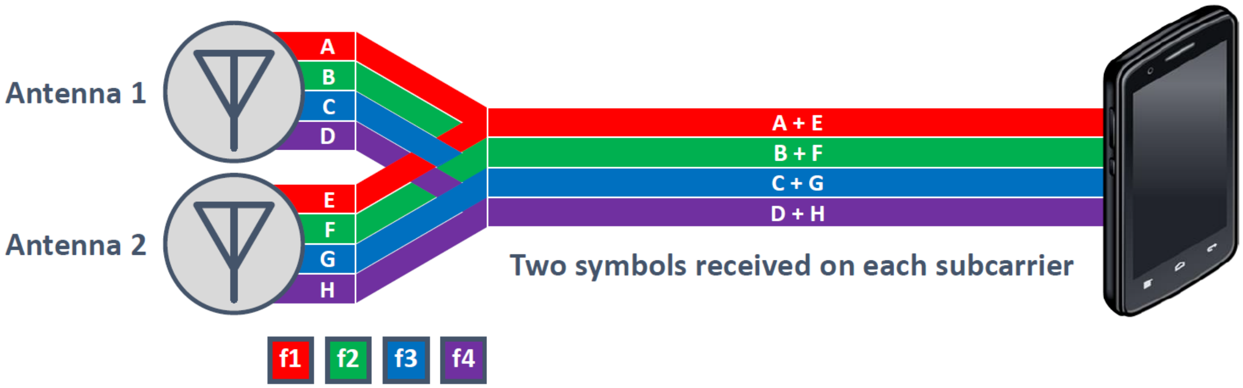
The term "subcarrier" does not appear in the claims of the CFO Patents as a standalone term, but rather in the context of the parties' proposed constructions for "null subcarrier," above. Given this context, only Defendants' construction is proper because, by including "MIMO," it necessarily makes clear that the claimed "null subcarrier" must be present at a subcarrier across *all* antennas—otherwise a non-zero value could be transmitted on that frequency, rendering the claimed system inoperable. *Ecolabs, Inc. v. FMC Corp.*, 569 F.3d 1335, 1345 (Fed. Cir. 2009) (finding that where claim language permits an operable construction, the inoperable construction is wrong).

The CFO Patents are directed to MIMO systems, meaning that the system includes a transmitter that transmits over multiple antennas and a receiver that receives the transmission over multiple antennas. *See, e.g.*, **'317**, 2:16-20, Abstract, Title; *see also* JCC at 4. Indeed, ***each and every*** embodiment of "the invention" and ***each and every*** section of the specification relate to a MIMO system. **'317,** 17:33-38 ("Various embodiments of the invention have been described. The invention provides techniques

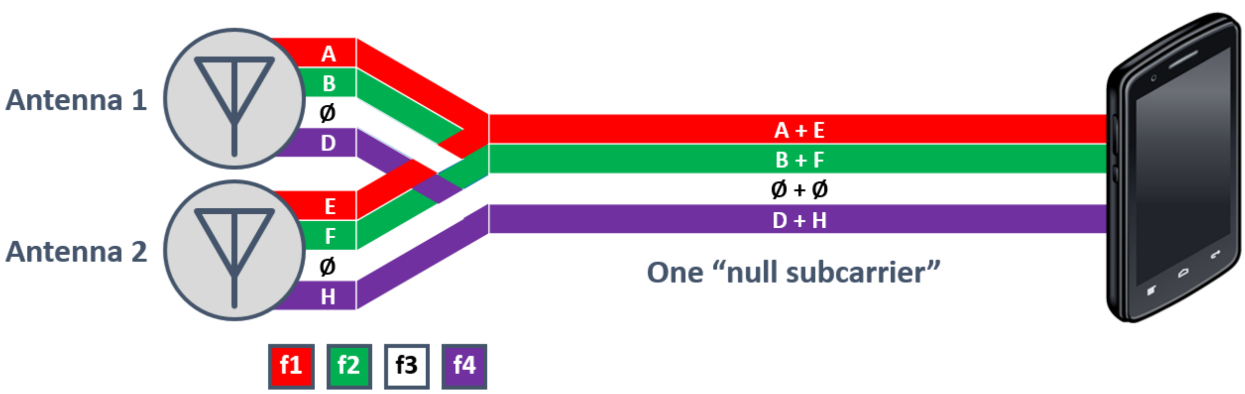
[8] The parties agree that the term "subcarrier" as used in the '230 Patent and CFO Patents should have the same construction. *Compare* JCC, Ex. A at 7-8 *with id*. at 14; *compare* Ex. B at 34-36 *with id*. at 46-47 (showing Plaintiff and Defendants respectively proposed the same constructions for "subcarrier" terms across all patents).

for carrier frequency offset (CFO) and channel estimation of [OFDM] transmissions over multiple-input multiple-output (MIMO) frequency-selective fading channels.”). Furthermore, the stated purpose of the invention is to provide an improved technique for estimating CFO in MIMO OFDM systems that is superior to prior art techniques related to single-input single-output (SISO) systems. ’317, 1:52-2:12; 3:15-26. Because every embodiment is limited to MIMO, and the invention is directed to improving MIMO, this term should likewise be so limited. *See Poly-Am., L.P. v. API Indus., Inc.*, 839 F.3d 1131, 1137 (Fed. Cir. 2016) (“Every embodiment described in the specification has inwardly extended short seals and every section of the specification indicates the importance of inwardly extended short seals. These two facts provide together a proper reason to limit the claims in this way.”); *Kaken Pharm. Co. v. Iancu*, 952 F.3d 1346, 1352 (Fed. Cir. 2020) (“A patent’s statement of the described invention’s purpose informs the proper construction of claim terms”).

In a MIMO system, the waveform transmitted through the channel consists of the combined output from all of the transmitter’s antennas. **VDW**, ¶132. As soon as each antenna transmits a signal, those signals instantly combine into a single waveform. **VDW**, ¶132. This is shown in the demonstrative below with respect to an exemplary two-antenna MIMO transmitter, where each transmit antenna transmits two symbols over one subcarrier (*e.g.*, C + G over subcarrier f3, in blue):



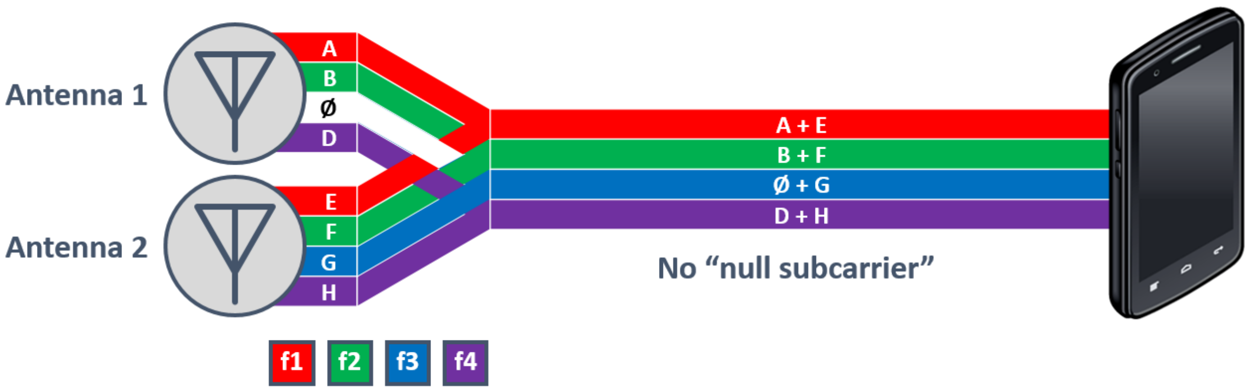
The CFO Patents describe that the receiver performs CFO estimation using null subcarriers. *See* Section III.A. In particular, because "the presence of CFO introduces a shift in the null space," the receiver estimates CFO by measuring the amount of that shift. *Id.*; '317 Patent at 9:37-38. As depicted in the demonstrative below, this null space (f3) is a result of transmitting two nulls (Ø) on the same subcarrier, resulting in Ø+Ø over subcarrier f3 (white). **VDW**, ¶136. Each transmitter ***must*** transmit a zero symbol at that subcarrier across every antenna, so that when combined, the total transmission at that subcarrier totals zero. **VDW** ¶136.



In this manner, the CFO patents allow the receiver to determine the shift of data values into the "null subcarrier," *e.g.*, from either the purple or the green subcarriers, due

to carrier frequency offset, thereby enabling CFO estimation. **VDW** ¶136. This approach is also consistent with the specification, which states that the number of zero symbols that are removed after CFO estimation is equal to N_t, which is the total number of antennas at the transmitter. *Id.*; **'317**, 10:36-54. In other words, by transmitting a null at that subcarrier on every antenna, a total of N_t zero symbols are transmitted. *See id.*; *see also id.* at 8:16-18 ("Applying the hopping code given in equation (8) inserts a zero symbol referred to as a null subcarrier in each block $\tilde{u}_{\mu}(k)$."). Thus, Defendants' clarification (within the context of the construction for "null subcarrier") properly ensures that a "null subcarrier" is a zero symbol across all antennas. *See Phillips*, 415 F.3d at 1315-16.

By contrast, allowing a "null subcarrier" to include a *non-null* transmission on the same frequency, but from a different antenna, would be contrary to the disclosed invention and would effectively render the invention inoperable for its intended purpose. **VDW**, ¶137. Specifically, if one or more antennas of a transmitter were to send a transmission on a subcarrier that was *not* null, the transmitter's combined waveform for that subcarrier would, in turn, be non-null. *Id.* As a result, for that subcarrier, the receiver would receive a signal that was not null. *Id.* As shown below, for example, where a zero symbol (Ø) is transmitted from antenna 1 on frequency f3, but a non-zero symbol (G) is transmitted over the same subcarrier (f3) on antenna 2, the entire subcarrier will be non-null (Ø+G):



Thus, due to the presence of the transmitted data value, symbol "G", the receiver, which is expecting no value on subcarrier f3, would be unable to detect the shift of other data values from either the green or purple subcarriers, as the CFO Patents require for CFO estimation. *See id.*; **'317**, 9:37-39, 9:55-67, 10:27-31, 14:27-37. Thus, to the extent Plaintiff's proposal for "subcarrier" allows the claimed "null subcarrier" to have a non-zero value on one or more antennas by not including the key clarifying word "MIMO," the construction should be rejected because the claimed system would be inoperable for its intended purpose. *See AIA Eng'g Ltd. v. Magotteaux Int'l S/A*, 657 F.3d 1264, 1278 (Fed. Cir. 2011) (holding that "a construction that renders the claimed invention inoperable should be viewed with extreme skepticism").

C. "form … blocks of symbols/output symbols" "forming blocks of symbols/output symbols" (CFO Patents, all asserted claims)

Defendants	Plaintiff
"Generating 'blocks of symbols' for transmission at consecutive times"	The terms "form" and "forming" do not require construction. The jury can apply the ordinary meaning of those terms.

The parties' dispute centers on whether the asserted claims require generating "blocks of symbols" for transmission at consecutive times. They do.

As captured by Defendants' construction, the specification exclusively describes the technique for forming blocks of symbols as generating ***consecutive*** blocks for transmission. **'317**, Figs. 2-3; 8:18-20; 13:23-28. In the only relevant discussion, the specification states that the generated transmission blocks "correspond to ***consecutive*** transmission blocks . . . at the output of one of training symbol insertion units 1**5**." *Id.* at 13:23-28 (emphasis added). These transmission blocks are "***generated***" by the transmitter. *Id*. at 13-23-25 (emphasis added). These explicit statements makes clear that the blocks of symbols are generated for transmission at consecutive times, in accordance with Defendants' construction.

Additionally, the alleged invention of the CFO Patents' would be inoperable for its intended purpose unless the blocks of symbols are generated for transmission at consecutive times. As one example, the equations for hopping and de-hopping codes (*i.e.*, equations 5, 8, and 9) require that blocks of symbols be generated for transmission at consecutive times. **VDW**, ¶¶141-142. Each of these equations uses the index "k"—representing consecutive transmissions of blocks—throughout the description of the claimed system. *See, e.g.*, **'317**, 8:18-20 ("Dependence of T_{sc} on the block index k implies that the position of the inserted null subcarrier changes from block to block."); 13:25-27.

As a second example, if blocks were not "formed" consecutively, the system would be unable to measure the amount of data in the null space caused by CFO. **VDW**, ¶143. As discussed above (*see* Sections III.A and III.B), the system estimates CFO by determining how much the data has shifted, due to the offset, into the null space via use of a disclosed "cost function." '317, 9:45. To ensure the null space is actually null, the "blocks of symbols" including the null subcarriers *must* be transmitted at consecutive times to ensure the entire transmission remains null at the null space. **VDW**, ¶143. If the null space is not actually null—that is, if it is purposefully contaminated by subcarriers with data values—the system will not operate as described because it will not be able to distinguish the offset from the contamination, and therefore it cannot attempt to minimize the CFO through the disclosed "cost function." **VDW**, ¶¶141-143. Only Defendant's construction prevents this result. *Ecolabs, Inc. v. FMC Corp.*, 569 F.3d 1335, 1345 (Fed. Cir. 2009) (finding that where claim language permits an operable construction, the inoperable construction is wrong); *see also AIA*, 657 F.3d at 1278 (holding that "a construction that renders the claimed invention inoperable should be viewed with extreme skepticism").

Accordingly, Defendants' construction is both compelled by the intrinsic record and necessary to ensure the claimed invention is operable for its intended purpose.

D. "block length" ('317 cls. 1, 19)

Defendants	Plaintiff
"The number of subcarriers in a block of symbols"	"The number of symbols in a block"

"position" or "positions" (CFO Patents, all asserted claims)

Defendants	Plaintiff
"Frequency range"	"The location of a symbol in a block of symbols"

Because "block length" and "position[s]" are related terms that refer to the general structure of OFDM block transmissions in the specification, Defendants brief the terms together for convenience. The parties agree that "blocks of symbols" refers to "a group of symbols for transmission at a given time." JCC at 3. The disputes here turn on whether, in the context of the specification, (1) the term "block length" means the number of the ***subcarriers*** within a block (Defendants) as opposed to merely the number of ***symbols*** in a block (Plaintiff), and (2) the term "position" means a ***frequency range*** (Defendants) or merely the ***locations*** of symbols in a block of symbols (Plaintiff).

First, the intrinsic record supports only Defendants' construction. The CFO Patents repeatedly define "N" as the "block length," with "N" being the number of subcarriers in a block of symbols. For example, the specification explicitly states that "[t]he OFDM block length is designed as N=64 as in HIPERLAN/2." **'317**, 15:26-32. The HIPERLAN/2 Standard, referenced in the CFO Patents, defines block length as the number of subcarriers, meaning "N" refers to 64 subcarriers. *See* Feuersanger at 1-3

(noting a length of 64 subcarriers); HIPERLAN/2 Standard; *see also* **VDW**, ¶148. The CFO Patents confirm that "N" corresponds to a number of subcarriers, not merely a number of symbols. **'317**, 14:39-45 ("Similarly, the signal-to-noise ratio (SNR) versus CRLB decreases as the number of blocks increases. If N>>N−K, i.e. ***the number of subcarriers*** is much greater than the number of null subcarriers, $T_{zp} \approx I_N$."); **'317**, 13:45-47 ("In some embodiments, N-K null subcarriers are inserted"). And the CFO Patents never equate the "block length" to the number of symbols in a block. Thus, the specification defines "block length" as N and "N" as **the number of subcarriers in a block of symbols**. *Biogen MA Inc. v. EMD Serono, Inc.*, 976 F.3d 1326, 1336 (Fed. Cir. 2020), *cert. denied*, No. 20-1604, 2021 WL 4507723 (U.S. Oct. 4, 2021) (adopting the "explicit definition of [the term] in the specification").

Second, Defendants' construction for "position" is supported by the specification, which, in describing the channel estimation and CFO mitigation techniques of the prior art, explains that "[i]n the IEEE 802.11a, IEEE 802.11g, and HIPERLAN/2 standards, sparsely placed pilot symbols are present in every OFDM symbol and pilot symbols are placed in the same positions from block to block." *See* **'317,** 1:60-64. In each of those systems, the "positions" within a block correspond to ***specific carrier frequency ranges***. *See* Feuersanger at 1-3; HIPERLAN/2 Specification; *see also* **VDW**, ¶148. Additionally, the claimed hopping code, which determines the positions of training symbols and null subcarriers in each block, determines *frequencies* at which the training symbols and null subcarriers are inserted in each block. **VDW**, ¶153. The CFO specification teaches that

the hopping code is given by the formula $T_{SC}(k)$, where "SC" stands for subcarrier. *See* **'317**, 8:10-24; *see also* CFO Provisional, 2 (identifying T_{SC} as the "null *subcarrier* insertion matrix").

Finally, a USPTO Examiner confirmed this definition of "position" during prosecution of U.S. Appl. No. 15/163,055, a continuation application of the CFO patents, by stating:

> [T]he claim limitation of "inserting training symbols and null subcarriers within the two or more blocks of information-bearing symbols at positions determined by a hopping code" as cited in claim 1 of US 8,774,309 ***has the same meaning of*** "inserting null values within the two or more blocks of information-bearing symbols so that ***the position of the null values switches among subcarriers over time***" as recited in claim 2 of the instant application.

15/163,055 FH at 3 (emphasis added). Thus, the Examiner correctly equated the "position" of the training symbols and null subcarriers with the "subcarriers," which are carrier frequencies. The intrinsic record accordingly dictates that "position[s]" refers to a frequency range.

Plaintiff's construction, on the other hand, only adds confusion and leaves the scope of the claims undefined. It should thus be denied. *Cordis Corp. v. Boston Scientific Corp.*, 561 F.3d 1319, 1337 (Fed. Cir. 2009) (noting that a purpose of the claim construction process is to minimize "the risk of confusion to the jury").

E. "inserting at least one training symbol adjacent to at least one null subcarrier" ('185 cls. 6, 15; '309 cls. 5, 19)

Defendants	Plaintiff
"Inserting, within a block, at least one training symbol at an adjacent frequency to at least one null subcarrier"	"placing at least one training symbol next to at least one null subcarrier"

This term, present only in dependent claims, requires insertion of a training symbol "adjacent to" a null subcarrier. However, the term is silent as to, and parties dispute, the context in which the training symbol and null subcarrier must be "adjacent." Only Defendants' construction is consistent with the claims, including the claims from which they depend, and the specification, in that it properly clarifies that the insertion must be ***at an adjacent frequency within a block***. Plaintiff's proposal, on the other hand, fails to capture the meaning of "adjacent" in the context of the claims and could be interpreted, untethered to the specification, as symbols on the same frequency, but transmitted in different blocks close in time.

Importantly, each independent claim from which these claims depend requires, among other things, (1) *forming blocks* of information-bearing symbols and (2) *inserting* training symbols and null subcarriers *within* these blocks.[9] The independent claims'

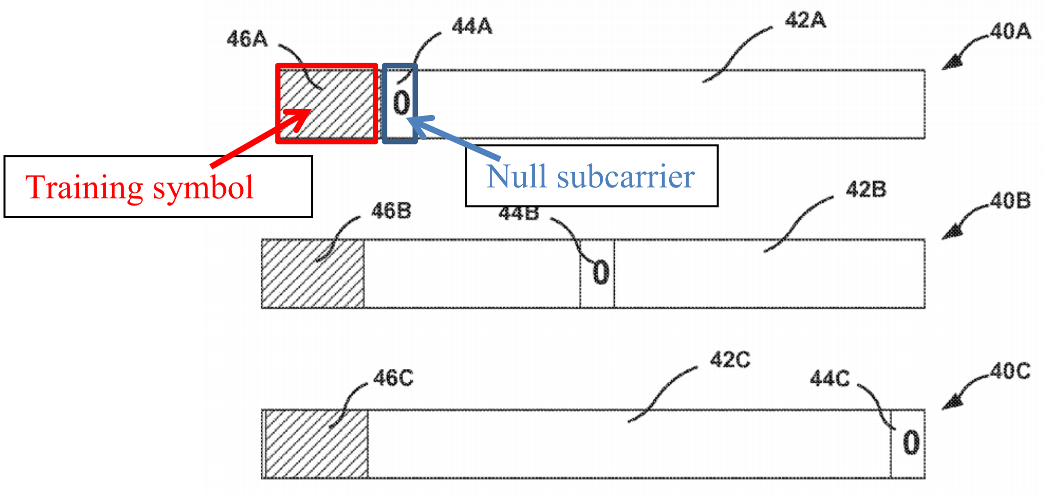
[9] *See*, *e.g.*, **'309**, cl. 1 ("*forming* two or more *blocks* of output symbols ... wherein the *forming* comprises encoding two or more blocks of information-bearing symbols for transmissions over the two or more antennas, and *inserting* training symbols

requirements of "forming" and "inserting" means that *the blocks* of information-bearing symbols must first be *formed*, and then the training symbols and null subcarriers are *inserted* into those blocks. *See* **'317**, 2:37-43, 5:32-43; *see also* CFO Provisional, 3 ("*After obtaining the information blocks*..., we first insert N_t training symbols...."). The disputed claim limitation—in the dependent claims—further limits *how* the at least one training symbol and at least one null subcarrier are inserted *within a block*. *See* Section III.B. ("Subcarrier"). Specifically, at least one training symbol and at least one null subcarrier are inserted *within a block at subcarriers adjacent to each other in that block*. *Id.* Each block is a one-dimensional vector spanning multiple ***frequencies*** at a given time (*i.e.*, one symbol (data value or a zero-value) per subcarrier, by the number of subcarriers in the block). **VDW**, ¶157. And, since subcarriers are frequencies (in the block of frequencies), the insertion is at an *adjacent frequency.*

In addition to the claim language, the specification confirms Defendants' construction. For example, the specification describes—and depicts with reference to Figure 3 (below)—the transmissions blocks described by these claims. Specifically, "*each transmission block* **40A-40C** includes space-time encoded information bearing symbols **42A-C**, null subcarriers **44A-44C**, and training symbols **46A-46C**, respectively." **'317**, 13:23-31; *see also* **CFO Provisional**, Fig. 2 (same).

---

and null subcarriers *within* the two or more blocks of information-bearing symbols at positions determined by a hopping code"); *see also* **'309**, cl. 16; **'185**, cls. 1, 9.



CFO Patents, Figure 3 (annotated)

Thus, although each of transmission blocks **40A**, **40B**, and **40C** (above) satisfies the independent claim requirements of (1) forming blocks of information bearing symbols and (2) inserting training symbols and null subcarriers into those blocks, *only* transmission block **40A** satisfies the disputed *dependent limitation* of "inserting at least one training symbol [**46A**] ***adjacent to*** at least one null subcarrier [**44A**]."

Thus, because the claims require that training symbols and null subcarriers be inserted into each *block*, and because each block is one-dimensional spanning multiple *frequencies*, the disputed limitation of the dependent claims requires "inserting, *within a block*, at least one training symbol at an *adjacent frequency* to at least one null subcarrier."

Defendants' construction is true to both the claims, read as a whole, and the intrinsic record. Plaintiff's proposal, however, is untethered to either and impermissibly attempts to broaden the claims to allow for the mere "placing" of at least one training

symbol "next to" at least one null subcarrier, unrestricted to being "adjacent to" each other within the blocks of information-bearing symbols each is required to be "inserted."

F. "training symbol" (CFO Patents, all asserted claims)

Defendants	Plaintiff
"symbols with a predefined value that can be used by the device that receives the symbol to determine a physical characteristic of the transmitted signals"	"In a transmission system, a symbol having a predefined value that is transmitted by the transmitter to enable a receiver to determine a parameter that can be used to decode other transmitted symbols."

The dispute as to this term is whether the training symbol is strictly limited to being used for decoding (Plaintiff) or not (Defendants), and whether the training symbol is strictly limited to the "transmission system" (Plaintiff) or not (Defendants).

The intrinsic record is clear and compels Defendants' construction. The CFO Patents consistently describe using a training symbol to determine one or more physical characteristic of the transmitted signals. For example, the specification describes using training symbols to determine CFO, channel interference, channel estimation, and phase noise. *See*, *e.g.*, **'317**, 2:16-3:26, 4:22-47, 14:9-32, 15:60-16:9, (describing using training symbols to determine CFO and channel interference); 7:37-52, 8:32-51, 16:22-54, (estimating CFO), 12:48-60 (using training symbols to estimate phase noise); 17:1-12 (using training symbols to estimate CFO, channel estimation, and phase noise).

Plaintiff's proposal is also flawed to the extent it would exclude almost all of the preferred embodiments discussed above. *Accent Packaging, Inc. v. Leggett & Platt, Inc.*, 707 F. 3d 1318, 1326 ("[A] claim interpretation that excludes a preferred embodiment from the scope of the claim is rarely, if ever, correct."). For example, the specification describes using certain training symbols to determine CFO—a characteristic of the transmitted signals—***not*** to decode. *Supra* Section III.A (explaining that null subcarriers, a class of training symbols, are ***exclusively*** used for CFO estimation). While it is true that each of the steps taken at the transmitter and receiver may ultimately assist in decoding, because decoding is typically the final step in the transmission process, inserting "used for decoding" into every step in transmission and reception is senseless, ***particularly*** where every claim except one does not require decoding. Finally, Plaintiff's proposal limits training symbols to a "transmission system," a term that never appears in the specification, and appears to exclude the receiver, contrary to every disclosed embodiment. *E.g.*, **'317**, 2:2-4. Defendants' construction, on the other hand, is true to the intrinsic record and should be adopted by the Court.

Dated: November 3, 2021

/s/ Nicholas Mathews
Nicholas Mathews (admitted *pro hac vice*)
Texas State Bar No. 24085457
nmathews@mckoolsmith.com
Warren Lipschitz (admitted *pro hac vice*)
Texas State Bar No. 24078867
wlipschitz@mckoolsmith.com
Casey Shomaker (admitted *pro hac vice*)
Texas State Bar No. 24110359
cshomaker@mckoolsmith.com
McKool Smith, P.C.
300 Crescent Court Suite 1500
Dallas, TX 75201
Telephone: (214) 978-4000
Telecopier: (214) 978-4044

Kevin P. Hess (admitted *pro hac vice*) Texas State Bar No. 24087717
khess@mckoolsmith.com
McKool Smith, P.C. 303 Colorado Street, Suite 2100 Austin, TX 78701 Telephone: (512) 692-8700 Telecopier: (512) 692-8744

Theodore Stevenson III (admitted *pro hac vice*) Texas State Bar No. 19196650
ted.stevenson@alston.com
Alston & Bird LLP
2200 Ross Ave., Suite 2300
Dallas, TX 75201
Telephone: (214) 922-3400 Telecopier: (214) 922-3899

Michael M. Lafeber (#242871)
Taft Stettinius & Hollister LLP
2200 IDS Center
80 South Eighth Street
Minneapolis, MN 55402
T: 612.977.8400
F: 612.977.8650

ATTORNEYS FOR DEFENDANT-

QUINN EMANUEL URQUHART & SULLIVAN, LLP

By: */s/ David Aaron Nelson*
Jonathan A. Strauss
Sonia L. Miller-Van Oort
SAPIENTIA LAW GROUP PLLC
120 S. 6th St., Ste. 100
Minneapolis, MN 55402
Telephone: (612) 756-7100
Facsimile: (612) 756-7101
jons@sapientialaw.com
soniamv@sapientialaw.com

David Aaron Nelson
Stephen Andrew Swedlow
Nathaniel Andrew Hamstra
Marc Lawrence Kaplan
QUINN EMANUEL URQUHART & SULLIVAN LLP
191 N. Wacker Drive, Ste. 2700
Chicago, IL 60606
Telephone: (312) 705-7400
Facsimile: (312) 705-7401
davenelson@quinnemanuel.com
stephenswedlow@quinnemanuel.com
nathanhamstra@quinnemanuel.com
marckaplan@quinnemanuel.com

Attorneys for Defendant-Intervenor Nokia of America Corporation

/s/ Benjamin Hershkowitz
Barbara P. Berens
Carrie L. Zochert
BERENS & MILLER, P.A.
80 S 8th St., Ste. 3720
Minneapolis, MN 55402
Telephone: (612) 349-6416
Facsimile: (612) 349-6416
Email: bberens@berensmiller.com; czochert@berensmiller.com

Benjamin Hershkowitz
Josh A. Krevitt

INTERVENOR ERICSSON INC.

s/ *David E. Finkelson*
Jason W. Cook
MCGUIREWOODS LLP
2000 Mckinney Avenue, Ste. 1400
Dallas, TX 75201
Telephone: (214) 932-6418
Facsimile: (214) 273-7483
Email: jcook@mcguirewoods.com

David E. Finkelson
George B. Davis
MCGUIREWOODS LLP
800 East Canal Street
Richmond, VA 23219
Telephone: (804) 775-1000
Facsimile: (804) 775-1000
Email:
dfinkelson@mcguirewoods.com;
adaly@mcguirewoods.com
gdavis@mcguirewoods.com

John A. Cotter
LARKIN HOFFMAN DALY & LINDGREN, LTD.
8300 Norman Center Drive, Ste. 1000
Minneapolis, MN 55437-1060
Telephone: (952) 896-3340
Facsimile: (952) 896-1599
Email: jcotter@larkinhoffman.com

Attorneys for Defendant Sprint Spectrum L.P. and Sprint Solutions, Inc.

/s/ Jeffri A. Kaminski
Mark G. Schroeder
MSchroeder@taftlaw.com
2200 IDS Center, 80 South 8th Street
Minneapolis, MN 55402
Tel: (612) 977-8450
Fax: (612) 977-8650

Frank C. Cimino, Jr. (pro hac vice)
Jeffri A. Kaminski (pro hac vice)
Laura Corbin
Robert Scott Roe
GIBSON, DUNN & CRUTCHER LLP
200 Park Avenue
New York, NY 10166-0193
Telephone: (212) 351-4000
Facsimile: (212) 351-4035
Email: bhershkowitz@gibsondunn.com;
jkrevitt@gibsondunn.com;
lcorbin@gibsondunn.com;
sroe@gibsondunn.com

Neema Jalali
GIBSON, DUNN & CRUTCHER LLP
555 Mission Street, Ste. 3000
San Francisco, CA 94105-0921
Telephone: (415) 393-8200
Facsimile: (415) 374-8409
Email: njalali@gibsondunn.com

Attorneys for Defendant AT&T Mobility LLC

/s/ David E. Finkelson
David E. Finkelson
George B. Davis
MCGUIREWOODS LLP
800 East Canal Street
Richmond, VA 23219
Telephone: (804) 775-1000
Facsimile: (804) 775-1000
Email: dfinkelson@mcguirewoods.com;
adaly@mcguirewoods.com
gdavis@mcguirewoods.com

John A. Cotter
LARKIN HOFFMAN DALY & LINDGREN, LTD.
8300 Norman Center Drive, Ste. 1000
Minneapolis, MN 55437-1060
Telephone: (952) 896-3340
Facsimile: (952) 896-1599
Email: jcotter@larkinhoffman.com

VENABLE LLP
600 Massachusetts Ave NW
Washington, DC 20001
Tel: (202) 344-4569
Fax: (202) 344-8300
fccimino@venable.com

Attorneys for Defendant Cellco Partnership d/b/a Verizon Wireless

Attorneys for Defendant T-Mobile USA, Inc.

CERTIFICATE OF SERVICE

The undersigned hereby certifies that a true and correct copy of the above and foregoing document has been served on November 3, 2021, via electronic mail to counsel of record for Plaintiff.

/s/ Nicholas Mathews
Nicholas Mathews